

Development and Demonstration of Resource and Conservation Technology



1988-1991



Environment Canada
Environnement Canada

Canada

92-03679/

Think Recycling!



Pensez à recycler !

This publication is printed on paper containing recovered waste.

Development and Demonstration of Resource and Conservation Technology

1988-1991



*Technology Development Branch
Environmental Protection
Conservation and Protection*

*Ce rapport est aussi disponible en français.
S'adresser à :*

*Publication de la Protection de l'environnement
Conservation et Protection
Environnement Canada
Ottawa (Ontario)
K1A 0H3*

©Minister of Supply and Services Canada 1991
Cat. No. En 40-11/15-1991E
ISBN 0-662-19127-7

TABLE OF CONTENTS

The DRECT Program- 1988-1991

<i>An Overview</i>	1
Project Timetable	6
DRECT Projects 1989-91	
<i>Lafarge Canada Inc.</i>	10
<i>Candevel Limited</i>	12
<i>Canadian Pacific Forest Products Inc.</i>	14
<i>Circronics - A Division of Gandalf Data Limited</i>	16
<i>Canadian Chemical Reclaiming Limited</i>	18
<i>Ecolomics Inc.</i>	20
<i>Les Industries Fournier Inc.</i>	22
<i>Metropolitan Authority of Halifax-Dartmouth and the County of Halifax, N.S.</i>	24
<i>International Pigments and Colours Inc.</i>	26
<i>Roofing Materials Disposal Company Limited (RMDC)</i>	28
<i>Re-Met Processing Inc.</i>	30
<i>Serrener Consultation Inc.</i>	32
<i>Superwood Ontario Limited</i>	34
<i>Thermonic Inc.</i>	36
<i>Centre de tri Gaudreau Inc.</i>	38
<i>Fossetic Inc.</i>	40
<i>Shigawake Organics Limited</i>	42
<i>Ottawa General Hospital</i>	44
<i>Pacware Systems Inc.</i>	46
<i>Prairie Masonry Research Institute (PMRI)</i>	48



AN OVERVIEW

The DRECT Program 1988 -1991

The Development and Demonstration of Resource and Energy Conservation Technology Program (DRECT) was established by the Federal Government in 1978. Since its inception, DRECT has provided financial support and technical advice to encourage the development of new technologies in waste management, and energy and resource conservation.

The objective of the DRECT program is the development and demonstration of new methods, systems, processes, and equipment that will reduce or eliminate waste generation, while saving energy and conserving resources. DRECT support is available for projects involving hazardous or non-hazardous wastes, in both industrial and municipal sectors.

DRECT invites applications and participation from industry, the private sector, provincial agencies, and municipalities. The program is designed to share the direct costs of an eligible project with the applicant. Up to 50% of the total estimated costs of approved projects, to a maximum of \$200 000 per year, may be funded under the DRECT program.

The DRECT program is co-funded by Environment Canada and the Federal Panel on Energy Research and Development (PERD). The program is administered by Environment Canada.

Since it began in 1978, DRECT has contributed approximately \$8.4 million to 59 projects across Canada. In response, industry, the private sector, provinces, and municipalities have directly contributed nearly \$34 million towards the development and demonstration of new technologies that benefit the environment and save energy. Selection of projects is based on technical merit, economic viability and market potential of the technologies proposed. Projects have been approved in all regions of the country.

AN OVERVIEW

Energy savings achieved through DRECT have been significant. Over the 13-year period in which the program has been active, direct energy savings from funded projects are calculated to exceed 3 000 000 GJ/yr, the equivalent of 470 000 barrels of oil (75 000 m³). In addition, there are indirect savings contributed by these technologies as new knowledge and expertise are transferred to the industrial and municipal infrastructures. These spin-off savings are harder to estimate but are calculated to be three to five times the direct savings.

The list of DRECT projects undertaken to date illustrates the variety of scientific and engineering skills and know-how that have been contributed cooperatively by industry and government under this program. Projects run the gamut from the demonstration of a prototype system for efficiently collecting sludges from septic tanks in rural areas, to the recycling and reuse of furnace dusts in the steel industry.

In total, twenty companies cost-shared the development of waste reduction/energy-saving technologies with DRECT over the past three years. Examples of companies that have proceeded to commercialize their technologies include:

Canadian Chemical Reclaiming Ltd., since March, 1989, has been successfully operating a mobile plant for reclaiming gas-treating chemicals used in the natural gas industry.

Centre de tri Gaudreau Inc. in 1988/89 addressed the difficult problem of recycling household wastes in a medium-sized community where economies of scale are not available. The Centre processed 10 000 t of materials in the two-year period of the DRECT study, representing some 25% of the wastes generated in the municipality.

Fossotie Inc. developed a new and much more efficient methodology for removing and managing septic tank sludge in rural areas. The company has subsequently licensed the technology to two other firms.

The status of these projects and others are described in this report.

The DRECT Program and Waste Management in Canada

The traditional attitude to solid waste management in Canada has been that effective waste management must focus on the rapid removal and disposal of the unwanted by-products of our society. However, with existing waste management systems reaching critical overload in terms of quantities and types of waste to be handled, the need for more effective use of resources to sustain both the integrity of our environment and the continued development of our economy is evident.

Governments at all levels across the country are developing broad-based waste reduction, reuse, and recycling strategies. In particular, the Canadian Council of Ministers of the Environment (CCME) has developed and adopted a national waste action plan which has, as a key objective, targetted a 50% reduction in the generation of wastes in Canada by the year 2000.

The DRECT Program, given its waste reduction/utilization focus and the expertise and experience generated in the thirteen years of its existence, is particularly well placed to support these initiatives.

Over the next two years, the DRECT program will be encouraging technology development in areas which promote the CCME objective and schedule. Examples of areas of particular urgency are: packaging, hospital wastes, and waste oil recycling/reuse.

Packaging. Municipalities and provinces have consistently identified that a key to achieving overall waste diversion objectives is the reduction of wastes resulting from packaging. The National Packaging Protocol, endorsed by the CCME in March, 1990, states that priority will be given to the management of packaging through source reduction, reuse, and recycling.

A series of targets has been established by the CCME as objectives for the management of packaging. These targets are as follows:

AN OVERVIEW

- i) By December 31, 1992, packaging sent for disposal shall be no more than 80% of the amount sent in 1988;
- ii) By December 31, 1996, packaging sent for disposal shall be no more than 65% of the amount sent in 1988;
- iii) By December 31, 2000, packaging sent for disposal shall be no more than 50% of the amount sent in 1988.

The problem is enormous and, without doubt, the timing is critical.

Hospital Wastes. Another important contribution to waste minimization priorities is work in the area of institutional wastes. A DRECT project is underway at the Ottawa General Hospital to develop a Model Hospital Waste Audit Process. The ultimate objective of further developments in this sector will be to establish an overall, integrated system for minimizing and managing hazardous and non-hazardous wastes in hospitals and other health care institutions.

Used Oils. There are two critical tasks to used oil management. The first is to collect the used oil and the second is to develop adequate means for handling the collected volumes.

Approximately one billion litres of lubricating oils are sold in Canada each year. About 50% of this volume is potentially recoverable as used oils. Today, only half of this recoverable portion is collected and the remainder is "lost" or used in environmentally inappropriate ways.

Used oils which are collected must be managed appropriately if environmental and resource conservation benefits are to be realized. The principles of sustainable development dictate the need to rerefine or reprocess used oils into useful consumer products or, alternatively, capture their energy as a fuel and thereby reduce consumption of non-renewable resources.

The CCME Code of Practice for Used Oil Management in Canada describes environmentally sound practices for handling, storage, collection, transportation, recycling, reuse, and disposal of used oils. Industry and governments realize, however, that the need exists to develop and institute approaches to collection

the need exists to develop and institute approaches to collection and recycling/reuse of used oils that are:

- a) effective in recovering the aforementioned lost litres;
- b) economically viable in a variety of applications and scenarios; and c) consistent with the CCME Code of Practice.

DRECT Project Timetable

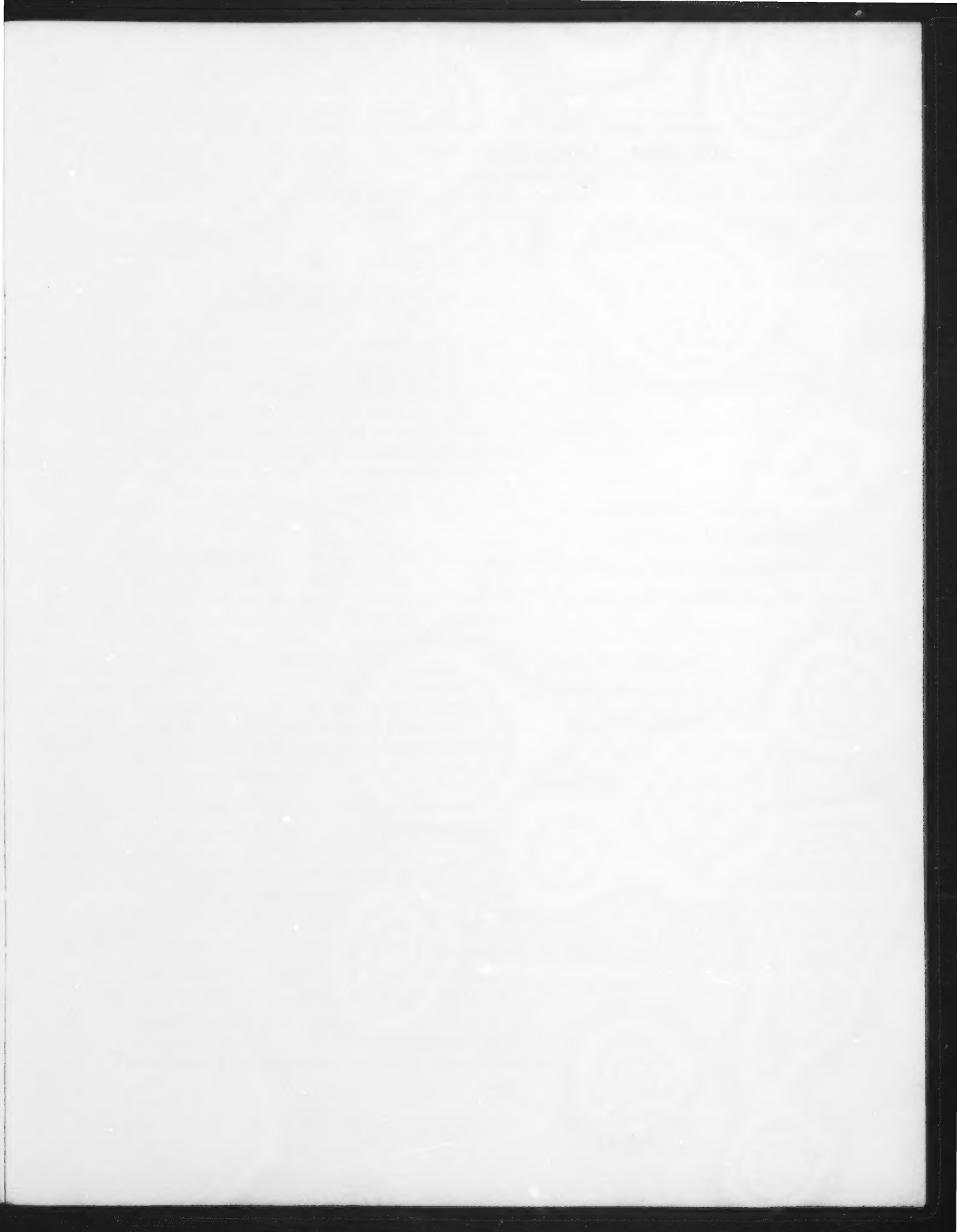
Project No.	Title	Timing		Scientific Authority	Location	Description
		Begin	End			
1.	IS 5 Vehicle	1978	1980	D. Campbell	Toronto, Ont.	Two-compartment truck for retrieval of glass and newspaper.
2.	Glass Cont Counc.	1978	1982	D. Campbell	Toronto, Ont.	Plant for cleaning waste glass for reuse as raw material.
3.	PEI Incinerator	1978	1984	A. Burgess	Charlottetown, PEI	One hundred tonne per day heat recovery incinerator plant.
4.	Custom Cryogenic	1979	1980	D. Campbell	Toronto, Ont.	Plant for cryogenic recycling of waste plastic and rubber.
5.	Roslyn Park Farms	1979	1982	A. Burgess	Petersburg, Ont.	Plant for mesophilic anaerobic digestion of cattle manure.
6.	AGPRO Industries	1980	1982	D. Campbell	Colborne, Ont.	Plant for composting municipal waste mechanically.
7.	Fuel Cube Manuf.	1980	1981	D. Campbell	Surrey, B.C.	Plant for producing wood stove fuel cubes from newspaper and coal fines.
8.	SWARU Incinerator	1980	1982	D. Campbell	Hamilton, Ont.	Steam to electricity generator for the SWARU municipal waste incinerator.
9.	Pet. Recyc. Serv.	1980	1981	D. Campbell	Toronto, Ont.	Vehicle for cleaning and filtering waste oil for resale to generator.
10.	Organic Recyc.	1980	1982	A. Burgess	Newmarket, Ont.	Vermicomposting to transform waste to soil additive.
11.	Ethanol from waste	1980	1983	A. Burgess	Kincaid, PEI	Plant for producing ethanol from cull potato waste.
12.	Northwest Rubber	1980	1981	A. Burgess	Pitt Meadows, B.C.	System for shredding tires to produce rubber mats.
13.	Fluidized Bed	1981	1982	A. Burgess	Halifax, N.S.	Fluidized bed furnace for burning waste coal in homes.
14.	Victoriaville	1981	1984	D. Campbell	Victoriaville, Que.	System for retrieving fine paper from schools.
15.	X-Pert Metal	1981	1985	W. Bissett	Burlington, Ont.	Electrochemical reactor for recovering cadmium, copper and zinc from effluent.
16.	Bakelite	1981	1983	D. Campbell	Belleville, Ont.	Recovery of phenol and recirculation of distillate to make phenolic resins.
17.	Nitrochem	1981	1988	W. Bissett	Maitland, Ont.	Mechanical compression system for evaporating water to recover ammonium nitrate.
18.	Canada Cement Lafarge	1981	1984	G. Girouard	St. Constant, Que.	System for burning rubber tires in a cement kiln.
19.	Landfill Gas	1981	1986	A. Burgess	Kitchener, Ont.	System for capturing methane from landfill and using it in industry.
20.	Potthoff Farms	1981	1983	A. Burgess	Orangeville, Ont.	System to burn flax straw to heat greenhouses.
21.	Dovercourt Metal	1981	1983	B. Christensen	Toronto, Ont.	System to recover and re-use chrome from effluent.
22.	AGROPUR	1981	1986	B. Christensen	Granby, Que.	Anaerobic fermentation of cheese plant effluent.
23.	Intl. Wood Millers	1982	1982	D. Campbell	Joliette, Que.	Plant to produce wood flour from wood waste.

DRECT Project Timetable

Project No.	Project Title	Timing		Scientific Authority	Location	Description
		Begin	End			
24	Hochelaga	1982	1983	B. Christensen	Montreal, Que.	Shredder-compactor trucks to retrieve confidential paper.
25	PEI Sludge Gas	1982	1984	A. Burgess	Charlottetown, PEI	Production of electricity from sludge gas.
26	CNR Transcona	1982	1983	B. Christensen	Winnipeg, Man.	Production of steam from railway car wastes in a modular controlled air incinerator.
27	CCL Waste Liquids	1982	1989	G. Rathbone	Woodstock, Ont.	Combustion of waste liquids burned in cement kiln.
28	MacMillan Bloedel Rubber	1982	1984	A. Burgess	Nanaimo, B.C.	Utilization of waste rubber tires as a hog boiler fuel.
29	Fossetic, Septic Tank Cleaning	1983	1986	G. Girouard	Sainte-Agathe des-Monts, Que.	An energy-efficient method of cleaning septic tanks.
30	Canadian Bronze Co. Ltd.	1984	1985	W. Bissett	Winnipeg, Man.	Purification and recovery of chromic acid in a chrome-plating operation (ECO-TEC System).
31	Torcad Ltd.	1984	1986	W. Bissett	Toronto, Ont.	A new technique (Chemelec Process) to recover toxic metals from dilute electroplating rinse waters.
32	Laidlaw Waste Systems	1984	1985	G. Rathbone	Kitchener, Ont.	Curbside collection of waste oil for supply to the re-refining industry.
33	Weston Graham & Associates Ltd.	1984	1985	J. Haskill	Dalkeith, Ont.	An experimental investigation on feeding wood pulp fines from the paper-making industry to livestock.
34	Anachemia Solvents	1984	1988	H. Dibbs	Mississauga, Ont.	Development of a system to combine solvent recovery with recovery of heat from residual industrial organic wastes.
35	Metal Koting	1985	1985	G. Rathbone	Rexdale, Ont.	Acid purification unit for use on concentrated high temperature pickling liquor (sulphuric acid).
36	Master Wash	1985	1985	C. Edwards	Edmonton, Alta.	Construction, operation and evaluation of a solvent recovery/recycling plant.
37	Halifax/Dartmouth	1986	1988	E. Hall	Halifax, N.S.	Construction and operation of an anaerobic landfill leachate system.
38	Canadian Pacific Forest Products	1986	1989	H.W. Campbell	Gatineau, Que.	Demonstration of a Kamyr ring press for dewatering pulp and paper primary clarifier sludge.
39	Nova Pb	1986	1988	C. Jose	Ste. Catherine, Que.	Demonstration of a system to recycle waste metallurgical dusts.
40	Energy Pathways	1986	1987	D. Campbell	Ottawa, Ont.	Development of a national program for on-site solutions to waste treatment problems.
41	Thermonic Inc.	1987	1988	G. Girouard	Boucherville, Que.	Demonstration of a treatment process for recovery of chrome VI from metal finishing wastewater.

DRECT Project Timetable

Project No.	Title	Timing		Scientific Authority	Location	Description
		Begin	End			
42	R. L. Pyne	1987	1988	H.W. Campbell	Toronto, Ont.	Demonstration of precipitation flotation process to produce marketable concentrates of metal from metal finishing sludges.
43	Agrinove Cooperative	1987	1988	G. Girouard	Ste. Claire de Dorchester, Que.	Demonstration of a protein recovery process for pretreating wastewater in the dairy industry.
44	Circtronics	1988	1989	J. Portugais	Nepean, Ont.	Demonstration of waste treatment/copper recovery system for waste-waters from a printed circuit board manufacturer.
45	Candeval Ltd.	1990		S.A. Ross	Sault Ste Marie, Ont.	Design and testing of a pilot facility for processing coal tar into marketable products.
46	Canadian Chemical Reclaiming Ltd.	1989	1991	J. Haskill	Brooks, Alta.	Development of a portable unit for recovery of waste gas treating chemicals.
47	Ecolomics Inc.	1990		S.A. Ross	Pickering, Ont.	Selective segregation and recovery of electric arc furnace dust.
48	Les Industries Fournier	1990		G. Girouard	Black Lake, Que	Development of the Rotary Ring Press for dewatering industrial sludges.
49	International Pigments and Colours Inc.	1989	1991	G. Girouard	St. Jean-sur-Richelieu, Que.	Treatment/recovery of chromium and lead compounds in the pigment industry.
50	Roofing Materials Disposal Company	1990		S.A. Ross	Burlington, Ont.	Development of a recovery process for roofing wastes.
51	Re-Met Processing Inc.	1989	1991	M.C. Campbell	Vancouver, B.C.	Iron-oxide recycling process for recovery of dusts from the steel industry.
52	Serrener Consultation Inc.	1990	1991	G. Girouard	Sherbrooke, Que.	Development of an improved technique for septage disposal.
53	Superwood Ontario Ltd.	1990	1991	D. Hutchison	Mississauga, Ont.	Recycling of mixed post-consumer plastic.
54	Centre de tri Gaudreau Inc.	1989	1991	F. Laperrière	Bois Francs, Que.	Demonstration of a model recycling centre in a medium-sized municipality.
55	Fossetic Inc.	1989	1991	G. Girouard	Sainte-Agathe des-Monts, Que.	Demonstration of an effective septage management system.
56	Shigawake Organics Ltd.	1991		S. A. Ross	Shigawake, Que.	Development of a process for recovery/recycle of fish processing wastes.
57	Ottawa General Hospital	1990	1991	F. Laperrière	Ottawa, Ont.	Development of a model waste audit process for hospitals.
58	Pacware Systems Inc.	1990	1991	S. A. Ross	Ottawa, Ont.	Recycling of waste PVC in the packaging sector.
59	Prairie Masonry Research Institute	1990		S. A. Ross	Edmonton, Alta.	Development of new masonry units using wood waste.



DRECT Contractor

Lafarge Canada Inc.
Woodstock, Ontario

Scientific Authority: D. Campbell
(819) 953-1119

Objective

To assess the technical and economic feasibility of firing liquid wastes in a cement kiln as a partial substitute for gas, oil, coke or coal, and to establish community acceptance of this supplemental fuel.

Project Description and Relevance

The manufacture of cement is an energy-intensive process, particularly in plants using the older "wet" manufacturing process. The use of liquid wastes as a supplemental fuel would be a way of maintaining the competitiveness of such plants. It is also attractive as an environmentally sound disposal method for these wastes. Waste chemicals of the type suitable for supplemental fuel require care in handling and disposal.

Industry in Canada generates approximately 1 million tonnes of combustible wastes per year. It is estimated that, of the wastes that would be suitable for use at Woodstock, as much as half are transported out of province for disposal or reuse. The rest of the wastes are handled within the province by incineration or landfilling. Using such wastes as supplementary fuel in cement kilns could eliminate a serious disposal problem while at the same time offer economic benefits to the plant.

A permanent resource recovery installation at Woodstock could replace 20% of the conventional fuel currently used at the plant. With approximately 20 000 000 L/yr of organic wastes generated in Ontario, potential net energy savings are estimated to be 460 000 GJ/yr (70 000 BOE).

Communities in the vicinity of plants contemplating the use of these fuels, however, are usually apprehensive about the environmental and health risks associated with plant emissions and transportation of waste materials. This project was designed to address these concerns also.

Status Report

The extended test burn demonstrated that all other aspects of the proposed waste management installation were technologically and environmentally satisfactory. However, as a result of observations during the test runs, the Ontario Ministry of Environment (MOE) identified several operating problems at the plant. Subsequent to the extended test burn, MOE requested that the plant improve fugitive dust control in a number of areas. A control order identified

twelve areas of concern and two more were added later. The company decided to delay applying for an environmental hearing to burn combustible wastes until it had complied with the requirements of the control order. Excellent progress has been made in this regard. Practical engineering solutions have been developed and installed and the improvements obtained have become a permanent part of the plant's operations.

DRECT Contractor

Candevell Limited
Waterloo, Ontario

Other Cost-Sharing Partners: Algoma Resources Inc.
St. Catharines, Ontario

Scientific Authority: S.A. Ross
(819) 953-7827

Objective

To develop and demonstrate a new technology to process coal tars (in an environmentally favourable manner), into two marketable products: coal tar pitch; and light oils.

Project Description and Relevance

Work under this contract involves the design, construction, start-up and testing of a pilot plant facility (capacity 18 L/min) for processing coal tar into two marketable products: pitch and light oils. The new technology not only has the potential to solve an environmental problem at an operating steel plant, but if proven to be commercially viable, could represent a major breakthrough in the processing of coal tar, resulting in significant energy-saving benefits to Canada.

Coal tar is a by-product of the coking process in the steel industry. The conventional method employed in processing coal tar into pitch and light oil products is by means of distillation. The distillation process is energy-intensive and a potential source of fugitive gaseous emissions.

The development to be evaluated uses solvent extraction instead of distillation as a means of producing pitch and light oils from coal tar. Laboratory studies indicated that pitch recovery efficiency by means of the extraction process was 32% to 34% by weight of untreated coal tar. The proponent suggests that by pretreating the raw coal tar to remove moisture, and by improving the quality of operation of coke batteries at the steel plant, the efficiency of the process can be enhanced to a 50% recovery rate.

Potential energy savings of the development over conventional distillation are impressive. At Algoma Steel in Sault Ste. Marie, the distillation of 182 000 L/d (40 000 gal/d) of coal tar consumes

energy at a rate equivalent to approximately 55 barrels of oil per day (BOE/d). The proposed process, if treating an equivalent volume of coal tar, would use an estimated 9 to 10 BOE/d. Annual energy savings at Algoma Steel alone would be in the order of 14 000 BOE.

The major technological risk associated with this development is operability of the mixing and separation processes. The problem is that pitch comes out of solution in the form of a large sticky mass. A method of handling this material requires development before full-scale application will be feasible. Another concern with the process is the environmental emissions that may occur. An environmental testing and evaluation program will be included as part of this

project to ensure the safety of the process, as well as the products it generates.

Status Report

The Company has designed and constructed a pilot scale extraction plant capable of pretreating and processing untreated coal tar at a rate of 18 L/min. It has also developed (in conjunction with the Scientific Authority) a test plan to evaluate the operating characteristics of the pilot facility under continuous coal tar feed conditions. A proposed environmental monitoring and evaluation program is being evaluated by the Ontario Ministry of Environment. A final report will be available by December, 1991.

Scientific Authority: H.W. Campbell
(416) 336-4717

Objective

To demonstrate the Kamyr Ring Press as an effective sludge dewatering system that will be applicable at pulp and paper plants across the country and will reduce sludge incineration and disposal problems.

Project Description and Relevance

CPFP Inc. has a sludge disposal problem at their Gatineau pulp and paper mill. Approximately 600 000 m³ (20 000 000 ft³) of sludge is stockpiled because the existing dewatering system cannot process it. The stockpile is growing at a rate of 140 m³/d.

At the CPFP Inc. facility sludge is collected in the primary clarifiers and then pumped to parallel belt/coil filters and a Riez "V" press. The combination filter-press system raises sludge dryness to 30% solids. At this level the sludge is not dry enough to be incinerated on its own. It is mixed with bark and then burned with the aid of auxiliary fuel (i.e., oil or gas).

Nationally, pulp and paper mills face similar problems. Sludge disposal is becoming more difficult as existing landfills are exhausted and new landfills become more difficult to find. In addition, leachate from pulp and paper sludge has been identified as a possible cause of groundwater contamination. Known problem sites include pulp mills near Thorold, Ontario, and La Tuque, Quebec. Concerns regarding groundwater contamination have caused provincial governments to become more stringent in monitoring and controlling disposal of pulp and paper sludge. New methods of sludge disposal must be found to solve the growing problem.

The ring press is Canadian technology developed by the Centre de recherche industrielle du Québec (CRIQ) and manufactured by Kamyr Inc. under a licensing agreement with CRIQ. The CPFP Inc. project represents the first environmental application of this technology and

presents an opportunity to obtain invaluable performance data. If successful, the system would be applicable at pulp mills across the country and would help alleviate a serious waste disposal problem. A drier sludge will reduce CPFP Inc.'s auxiliary fuel consumption by the equivalent of 20 000 bbl of oil/yr (3200 m³ of oil/yr). If used at pulp mills on a national scale, energy savings are estimated at 200 000 bbl of oil/yr (32 000 m³ of oil/yr).

Status Report

CPFP Inc. installed a 120-cm ring press at its Gatineau mill in 1987 and has completed a successful test program with the unit. The press increased sludge dryness to the 40 to 50 % solids level, reduced the need for auxiliary fuels, and simplified the disposal of the sludge. Total cost savings are estimated to be \$ 453 000.00/annum.

DRECT Contractor

Circtronics (A Division of Gandalf Data Limited)
Nepean, Ontario

Other Cost-Sharing Partners: Ontario Ministry of Environment

Scientific Authority: J. Portugais
(819) 953-1136

Objective

To demonstrate the technical and economic viability of a copper recovery/waste management system for a printed circuit board manufacturing facility.

Project Description and Relevance

The photographic, machining, and chemical processing areas at a printed circuit board manufacturing plant all consume water for rinsing, cooling, lubricating, and chemical processing; and so, produce wastewater. These wastewaters are contaminated with organics, copper, tin/lead, and nickel. These wastewaters must be pretreated before being discharged into municipal sewers or they must be recycled within the plant.

Various alternatives have been evaluated for treating complexed metal-bearing wastes. In general, high costs and the resulting hazardous sludges make these alternatives unattractive.

The process proposed at Circtronics was a "no-sludge" technology that was developed in Canada and evaluated at two printed circuit board manufacturers in the United States. Ion exchange is used to remove copper from the contaminated rinse waters and an electrochemical reactor is used to recover copper from the product of the ion exchange column and from copper bearing bath dumps.

No system of this kind had been demonstrated at a printed circuit board manufacturing plant in Canada. The size of Canadian facilities, compared to the U.S. test facilities, necessitated design and operating changes to keep the technology competitive.

Direct energy savings possible for the 38 printed circuit board manufacturing plants in Canada have been estimated at equivalent to at least 70 000 bbl of oil/yr (11 100 m³/yr). However, the

potential applications of this technology to other industrial sectors such as metal finishing, electronics manufacturing, and the mining industry could greatly increase the energy savings.

Energy savings can also be envisaged from the reduction of the impact on municipal sewage treatment plants. Municipal sludges containing excessive metallic contaminants cannot be applied to land and must be disposed in an approved manner, such as incineration. The incineration of one tonne of digested sewage sludge consumes approximately 4 000 000 kJ of energy. Nationally, this energy requirement would be in excess of 300 000 barrels of oil per year (48 000 m³/yr).

Status Report

The project is now complete. The results indicate that the process and the equipment provided significant

reductions in copper in the effluent but did not fully reach the performance levels targetted. The process lowered the average copper concentration in the effluent to 1.7 mg/L, which is well below the sewer by-law limit (5.0 mg/L), but not quite the 1.0 mg/L or less predicted. Nearly two tonnes of commercial grade copper were recovered, with a value of \$3700 (against first year operating expenses of \$25 770). The cost of processing 150 barrels of copper sludge would have been \$37 500, producing a net cost advantage to Cirtronics of \$15 430.

Operating problems principally involved the failure of inadequately designed equipment. The system showed sufficient promise to continue the work to refine and improve it. The process does not offer a return on investment on the basis of copper recovery, but is economically attractive compared to other waste management options.

Scientific Authority: J. Haskill
(819) 997-3714

Objective

To develop and demonstrate a portable chemical processing unit for recovering waste gas-treating chemicals in the natural gas industry.

Project Description and Relevance

Gas-treating chemicals (GTCs) are used in the petroleum industry to remove acid gases such as H_2S and CO_2 and/or water vapour from natural gas. Normally, GTCs are employed in a water solution. The solution is circulated through an absorber counter-current to the flow of natural gas. Following treatment, the absorbed acid gases and water vapour are removed from the GTC by means of steam stripping.

Over time, as a gas-treating chemical is used in an operating plant, there is a tendency for non-regenerable contaminants to accumulate in the GTC solution. When the solution reaches a certain level of contamination, it is no longer effective in treating acid gas. At that point, it becomes necessary to remove the GTC from the gas-treating plant and replace it with a virgin solution. Waste GTCs are classified as hazardous materials and in western Canada are disposed of at the Alberta Special Wastes Treatment Centre at Swan Hills.

Contaminants which build up in GTCs include materials such as the reaction products from the thermal degradation of the GTC, heat stable salts (including sodium thiosulphate, sodium thiocyanate and sodium sulphide), asphaltenes, lighter hydrocarbons, and suspended solids.

There are numerous gas-treating chemicals employed in the petroleum industry. Chemicals commonly encountered include monoethanolamine (MEA), diethanolamine (DEA), methyldiethanolamine (MDEA), ethylene glycol, diethylene glycol, triethylene glycol, di-isopropylamine, sulphalene, and sulphanol.

The recovery of waste glycols, amines, sulphanols, and sulphalenes has been tried using numerous filtering and centrifuge devices. These efforts have proven unsuccessful.

A new technology to recover waste GTCs has been developed at Canadian Chemical Reclaiming Ltd. Based upon the principle of vacuum distillation, the purification process is designed to produce reclaimed chemicals of commercial quality.

A preliminary market survey completed in western Canada by Canadian Chemical Reclaiming Ltd. indicated that a minimum of 1 800 000 litres of gas-treating chemicals were being disposed of on an annual basis. Based upon this figure, the potential energy savings associated with reclaiming and reusing 90 % of these materials are

equivalent to 15 000 barrels of oil per year (2400 m³/yr). The cost of the reclaimed chemicals is estimated to be 70 % of the cost of virgin chemicals.

Status Report

The portable chemicals reclaiming plant has been in operation since March, 1989. A wide range of gas-treating chemicals are being successfully recovered. These include: diethanolamine (DEA), ethylene glycol (EG), sulfinol, ucarsol, diethylene glycol (DEG) and triethylene glycol (TEG). These have been returned to the original supplier or, in some cases, other suppliers.

The technology has been proven and offers new horizons to gas plant operators.

DRECT Contractor

Ecolomics Inc.
Don Mills, Ontario

Other Cost-Sharing Partners: Ontario Hydro
LASCO Steel

Scientific Authority: S.A. Ross
(819) 953-7827

Objective

To demonstrate the technical feasibility and the economic practicability of selectively segregating electric arc furnace dust into Zn-rich and Fe-rich fractions while still entrained in a gas stream.

Project Description and Relevance

In recent years, the treatment and disposal of electric arc furnace (EAF) baghouse dust has been receiving increased attention. The dust is classified as a hazardous waste material which prohibits its disposal at other than controlled landfill sites. The dust also contains certain metals, notably iron, zinc, and lead, which may be economically recoverable.

In Canada, there are ten mini-steel plants generating 100 000 to 125 000 tonnes of EAF dust per year. Although composition of the EAF dust is influenced directly by the type of scrap being melted and the operating conditions of the furnace itself, analyses of dusts arising from melting carbon and low-alloy steels typically result in the following range of concentrations (percent by weight): Cd, 0.03 to 0.15; Pb, 1.09 to 3.81; Zn, 11.12 to 16.9; and Fe (total), 24.9 to 46.9. Melting stainless steel and specialty alloys results in EAF dusts of the following chemical composition (percent by weight): Cd 0.006 to 1.79; Pb 0.23 to 0.78; Zn 1.77 to 6.22; and Fe (total) 22.2 to 35.5.

The options for recovery of metals from EAF baghouse dust have been examined in several recent projects. Pyrometallurgical and hydrometallurgical processes have proven to be technically feasible, but because of the large capital investment and high operating costs, the disposal of dust by landfilling is still the least expensive option.

The aim of this project is to develop a method of concentrating zinc (along with lead and cadmium) according to its physical properties by diverting non-ferrous fractions in the EAF flue gases. The dusts will be directed to separate dust collection chambers. Concentrating separate zinc and iron fractions of the EAF flue dust in this manner potentially results in several direct benefits, including:

- 1) production of zinc-rich and iron-rich materials that can be used as a raw feed at zinc refineries and steel plants, respectively;
- 2) reduction or elimination of 100 000 to 125 000 t/yr of hazardous waste;
- 3) significant energy savings over alternative technologies (combustion or chemical separation) for recovering metals from EAF dusts; and
- 4) energy credits and resource conservation benefits as a result of recovering base metals from EAF dusts as opposed to mining, smelting, and refining such metals.

Phase 1 of the project is a technical assessment of the proposed selective segregation process. This phase will attempt to demonstrate that: zinc content of the Zn-rich fraction of segregated EAF dusts is greater than 50 %; iron-content of the Fe-rich fraction of segregated EAF dusts is in the order of 60%, zinc content is less than 5 %, and the combined lead and cadmium content is less than 2 %; and further

demonstrate that products obtained by selective segregation of EAF dusts in the dust collection duct work of a mini-steel mill can meet specifications as raw feed materials for zinc refineries and steel plants.

Phase 2 of the project, an economic assessment of the proposed technology, will proceed upon achievement of the Phase 1 objectives. Successful completion of Phase 2 will:

- confirm the quantities of saleable metal dusts available for recovery in a fully-operational selective segregation process;
- evaluate the overall economics of applying a full-scale EAF dust segregation process at LASCO (or other existing Canadian steel mill) with due consideration to alternative methods of EAF dust management;
- determine the potential environmental and energy-saving benefits of a full-scale EAF dust segregation process.

Status Report

The project got under way in October 1990 with the fabrication, testing and installation of a sampler in the furnace ducting. Phase 1 of the project was completed in February, 1991. Data from this phase of the program are being evaluated. A final report is expected in December, 1991.

DRECT Contractor

Les Industries Fournier Inc.
Black Lake, Quebec

Other Cost-Sharing Partners: Centre Saint-Laurent,
St. Lawrence River Action Plan

Scientific Authority: G. Girouard
(514) 283-6536

Objective

To research, develop, and demonstrate a Rotary Ring Press that is capable of dewatering a variety of industrial sludges.

Project Description and Relevance

Sludges discharged from industrial and municipal wastewater treatment plants or industrial processes, are dewatered primarily to reduce the volume of waste material that must be transported to a final disposal site. If the site is an incinerator, as is the case for some industrial and municipal sludges, a dryness of about 35 % solids is required for self-sustained burning. If a landfill site is used, a dryness of 18 to 32 % is typically required. These restrictions are increasing, however, as municipalities and commercial landfill owners attempt to control the volumes of waste being disposed, increase the physical stability of their sites, and decrease nuisances.

Centrifuges, filter presses, and belt filter presses are normally used to dewater industrial and municipal sludges. Centrifuges produce a maximum "cake" - the non-fluid form of the dewatered sludge - with dryness of about 30 %, but have maintenance problems and high power requirements. Filter presses, which are becoming more popular, produce a high cake dryness (30 to 40%). They have, however, high capital and operating costs, large space requirements, and operate on a batch basis. Belt filter presses, currently the most popular of the three, are inexpensive, and have low power requirements. Nevertheless, the cake dryness they produce is less than 25 %. All three have a solids capture rate of more than 90 %.

The rotary press was developed at Le Centre de recherche industrielle du Québec (CRIQ), originally for dewatering peat, and pulp and paper

sludges. The patent on the ring press is held by CRIQ and an exclusive licence was granted to Les Industries Fournier for all applications other than in the pulp and paper, peat, and sugar beet industries in North America. This company holds the rights for all other applications related to the environment around the world.

This project involves the design and construction of a mobile experimental rotary ring press which will be transported to three preselected industrial sites for evaluation and development. The outcome of the

project will be design and operating criteria for full-scale sludge dewatering equipment to be used by industry along the St. Lawrence River and elsewhere in Canada.

Status Report

The fabrication of the Ring Press is approximately 80% complete and work is in hand to fabricate its 48-ft (15-m) trailer, as well as a 32-ft (10-m) trailer that will serve as a mobile laboratory. Field testing is expected to commence in July, 1991. The project is scheduled for completion in March, 1992.

DRECT Contractor

**Metropolitan Authority of Halifax-Dartmouth
and the County of Halifax, N.S.**

Other Cost-Sharing Partners: Province of Nova Scotia

Scientific Authority: E.R. Hall
(416) 336-4715

Objective

To demonstrate anaerobic
upflow fixed film reactors as a
method of treating
high-strength, toxic landfill
leachate.

Project Description and Relevance

The Metropolitan Authority of Halifax-Dartmouth and the County of Halifax operate a regional landfill site between Sackville and Mount Uniacke, Nova Scotia. The site receives approximately 1100 tonnes of refuse per working day and covers an area of 146 hectares. Leachate generated at this site is collected in an underdrain system which currently drains into two Hypalon-lined lagoons.

Leachate is a high-strength toxic waste with characteristics that depend on the type of refuse deposited, the type of soil cover, the method of landfilling and the hydrologic regime in which the refuse is placed. Leachate generation is distinctly site-specific. Although models have been developed for prediction of leachate quality and quantity, their accuracy is limited by their dependence on operating uniformity, climate, and the heterogenous nature of the landfill. These models are useful for landfill design, but are of limited value for design of final treatment systems.

The most commonly used techniques for leachate treatment are soil attenuation and the extension of municipal sewer services to landfills. For large landfills in remote locations, on-site treatment is required before leachate effluents are discharged to receiving waters.

The metropolitan authority proposes to develop and demonstrate a leachate treatment system at the site on Highway 101. The system will consist of:

- 1) pH adjustment to remove inhibitory metals;
- 2) anaerobic upflow fixed film reactors;
- 3) sludge handling facilities; and
- 4) polishing lagoons (aerated and facultative).

The use of an anaerobic upflow fixed film reactor system for on-site leachate treatment is unique within Canada. If successful, the system will help alleviate a toxic waste disposal problem by providing data useful in the design and operation of leachate treatment systems across the country. In addition, the anaerobic system has the potential to produce methane gas at a rate equivalent to 1900 bbl of oil/year (300 m³/yr). The biogas will be used to heat the control building and the anaerobic reactors.

Status Report

The anaerobic-aerobic treatment system is now in routine operation treating all leachate discharged at the Metro Halifax landfill site. Earlier difficulties associated with scaling of piping and heat exchangers have been ameliorated by the addition of a commercial anti-scaling agent to the system on an as-required basis. Both anaerobic reactors have also been refitted with new media in the upper packed bed zones. The depth of the packed zones has been reduced by one layer of media. The operators of the treatment facility have completed a laboratory-scale study to assess the benefits of adding low levels of cationic polymer to the anaerobic reactors to improve biosludge retention and to reduce effluent suspended solid levels.

The final report for this project is currently being reviewed by staff of the Wastewater Technology Centre and will be available shortly.

DRECT Contractor

International Pigments and Colours Inc.
St-Jean-sur-Richelieu, Québec

Other Cost-Sharing Partners: Centre Saint-Laurent
St. Lawrence River Action Plan

Scientific Authority: G. Girouard (819) 283-4252

Project Description and Relevance

International Pigments and Colours Inc. (IPC) is a Canadian company that annually produces about 2 700 000 kg (6 000 000 lb) of pigments for use in coatings, plastics, inks, and industrial paints. Approximately 95 % of the total production is inorganic metal-based compounds of lead and chrome.

Objective

To develop and demonstrate a treatment/recovery process for reclaiming chromium and lead compounds from pigment manufacturing process wastewaters.

The major sources of process wastewater are the raw material mixing tanks, and the filter press filtrate. Presently, these sources are responsible for material losses of 500 kg/d which currently go to Stablex or are discharged directly to the Richelieu River. The river discharge contains approximately 45 kg/d of chromium (66 mg/L). Given the current cleanup initiatives on the St. Lawrence River, the subject proposal has strong environmental relevance.

IPC has, over the last year, explored several alternatives for treating their wastewaters. It was concluded from their review that conventional treatment employing chemical precipitation was the least desirable because of the large capital and operating costs, and the production of large quantities of metal-laden chemical sludges.

IPC, after performing some pilot work on several treatment configurations, proposed to treat the wastewater with lead nitrate (used in pigment production) which would precipitate the hexavalent chromium as a yellow pigment. The resulting product can be recycled into the process stream for inclusion in various products.

The recovery of the 500 kg/d of recyclable material represents:

- 1) an increase in the product yield per unit of energy input - estimated energy use in the production of 500 kg/d of recyclable material is 740 000 000 kJ/yr (700 000 000 BTU/yr or 110 BOE/yr);
- 2) an increase in product yield per quantity of raw material used (approximate daily use - 364 kg lead oxide and 226 kg sodium dichromate) - estimated energy required by Canadian chemical suppliers for the above raw materials is 2×10^9 kJ/yr (1.9×10^9 BTU/yr or 340 BOE/yr); and
- 3) the elimination of off-site disposal of about 230 t/yr of metal-bearing sludges - estimated energy required for various reactants/concrete to neutralize the waste is 675×10^6 kJ/yr (6.4×10^8 BTU/yr or 114 BOE).

On an industry-wide and inter-industry basis, the savings through recovery of metal ions and pigment will be much

greater than for an individual firm like IPC. The IPC initiated treatment procedure, using lead nitrate and further refinements to the technology, will result in smaller volumes of sludge than the classical systems currently in use by many manufacturers, lower wastewater treatment costs and operating costs, an inexpensive source of raw feed material for the pigment industry, and a reduction in metal-laden liquid and sludge discharges to the environment.

Status Report

Results from monitoring of recoveries obtained by the project are positive. Indications are that lead chromate PbCrO_4 is being recycled at the design levels. Effluent levels from the plant are meeting discharge limits. A final report will be available in September 1991.

Scientific Authority: S. A. Ross
(819) 953-7827

Objective

To develop and demonstrate a new process for recycling asphalt roofing wastes directly into marketable products.

Project Description and Relevance

Used roofing shingles are not generated in very large quantities but the problem of their disposal is still significant. The Hamilton/Burlington area generates about 6000 t/yr. However, as the costs of disposal rise, the problem is economically important for the companies involved. For example, landfill costs to the proposer have increased from \$35 to \$116/t in the last two years. A further concern is the intention of some municipalities to ban roofing waste completely from their landfills.

Since roofing contains about 20 % asphalt, recycling it into other products which require asphalt will produce energy savings at the same time as the waste disposal problem is reduced. The energy content of asphalt wastes is about 10 GJ/t and the 450 000 tonnes which could be diverted from landfill therefore represent a potential savings of 750 000 BOE/yr.

This project involves the development and demonstration of a processing plant to convert used roofing shingles into usable products. Three marketable products will be developed:

- 1) Bumper Blocks;
- 2) Paving Stones; and
- 3) Asphalt Composition Mix.

The process envisaged involves the construction of a prototype plant to grind, heat, densify, and extrude the waste roofing material into the desired products. The intent is to utilize the asphalt, the principal binder in the used roofing material, as

the binder in the new products. The capacity of the equipment will be 2 t/h.

The prototype plant will be used to demonstrate the viability of the process, to produce the product which can be checked for quality and test marketed and to determine the commercialization potential of the new technology.

Status Report

A test processing line has been installed and operated to prove bulk waste shredding. A number of problems have been met and solved. A potential market was recognized for granulated asphalt roofing wastes and further work was done on the line to produce quantities of this material.

The project is scheduled to be completed in December 1991.

Scientific Authority: M. C. Campbell
(613) 996-2929

Objective

To develop and evaluate an iron-oxide recycling process for recovery of dusts from the steel industry.

Project Description and Relevance

The steel-making companies in the Great Lakes region generate large quantities of iron oxide fines, in excess of 300 000 t/yr, from their blast furnaces (BF), basic oxygen furnaces (BOF), and electric arc furnaces (EAF). Most of these oxides cannot be recycled safely or economically by the individual steel-makers as the oxides are too fine and are contaminated with zinc, lead, and alkali metals. Consequently, the majority of waste oxides are stockpiled, utilized as landfill, or in the case of those with high values of lead and zinc, disposed in specially developed landfill sites. The iron, zinc, and lead contained in these recyclable iron oxide fines are therefore being lost as a potential high grade source of metal.

Dusts that are generated by furnaces in steelmaking plants are recovered using cyclones, electrostatic precipitators, or conventional bag-house dust collectors. Some collected dusts are being recycled but, because of quality control concerns in the steel-making process, the majority of dusts are landfilled. Disposal of waste dusts at a controlled landfill is becoming costly for steelmakers, particularly as existing sites reach their capacity and new sites become farther removed from the point of waste generation. In addition, the burden of responsibility for steel companies includes the long-term environmental concerns that are associated with dust disposal by landfilling.

Dusts from electric arc furnaces contain zinc in readily soluble forms. If placed in a landfill, this zinc may be leached into groundwater creating a potential danger to the surrounding environment.

For this reason, electric arc furnace dusts have been classified as a hazardous industrial waste in Ontario (Regulation 309, *Environmental Protection Act*) and must be handled and disposed of in accordance with regulated requirements. Blast furnace and open hearth furnace dusts, which form the majority of generated dust, present another dimension to the problem. Although the zinc contained in these wastes is largely combined with iron as zinc ferrite and is less soluble at normal pH levels, its solubility can be significantly increased by lowering the pH of the leachate water. Acid rain, therefore, adversely affects the leachability of zinc in landfills containing blast and open hearth furnace dusts, causing latent environmental problems.

The technology for waste oxide dust recycling was researched and developed in the 1950s and 1960s, but widespread interest within the industry did not start until the 1970s. At present, no commercial oxide recycling plant exists in North America. In Japan, waste oxide recycling technology is well established; most commercial-scale operations are designed to reduce and "dezincify" the steelmaking dust using rotary kilns. In the Japanese process, dust fed into the kiln is heated and reduced to iron and zinc. Iron pellets produced in the rotating kiln are used as a raw material for blast furnaces and fines for sintering

plants. Evaporated zinc is reoxidized in the free space of the kiln and collected as zinc dust. The collected zinc is sold to zinc refiners. Carbon monoxide, which is generated as a result of the reduction reaction, is combusted in the kiln creating a source of heat, and saving fuel.

Re-Met Processing Inc. proposed to demonstrate the feasibility of an iron oxide recovery/recycling plant of similar design to plants in Japan. This included a technical and economic evaluation of the situation in southern Ontario, using feed stock from the four mills in question and a pilot plant simulation of the Japanese rotary kiln operation. If successful, the project would constitute a major breakthrough in waste management/energy recovery in the iron and steel industry.

Status Report

Re-Met has successfully completed the project and has concluded that a recycling plant is viable. Negotiations are in progress with the four major steel companies in southern Ontario.

The Re-Met plan includes the development of a central facility in Hamilton with the capacity to recycle 325 000 t/yr of steel-making dust. Such a plant would divert 325 000 m³ of waste from landfills. The estimated cost of the plant is \$40 000 000.

DRECT Contractor

Serrener Consultation Inc.
Sherbrooke, Quebec

Other Cost-Sharing Partners: Fafond et Freres
Valoraction Inc.
MRC - Portneuf

Scientific Authority: G. Girouard (514) 283-6536

Project Description and Relevance

The process of the MEDIAFLEX filter system is based on a combination of filtering materials acting synergistically. The combined effects of multiple layers of various filtering materials selected for specific treatment applications ensure maximum removal efficiencies and problem-free operation, with this low-technology, low-energy consuming system.

Objective

To demonstrate a technique for the improved treatment of septage using the MEDIAFLEX filter process.

The first layer in the MEDIAFLEX filter is specifically selected for its ability to remove pollutants, mainly due to cellular structure, high specific surface, porosity, and ion exchange capacity. Filtration proceeds through four mechanisms - ion exchange, metal complexing, and adsorption and filtration of particulate matter.

The second layer filtration mechanism is based on chemical adsorption and precipitation as well as the absorption and filtration of particulate matter. This medium thereby removes organic matter, metals, matter in suspension, and colour. It also provides complete bacterial stabilization and consequently reduces the foul smell of wastewaters.

Metals which precipitate at pH values between 9 and 12 are also retained and the effluent alkalinity resulting from the filtration medium is easily remedied by subsequent aeration. Natural aeration lowers the pH to neutrality.

The third layer is sand which retains solids, namely, metallic hydroxide precipitates, and constitutes an essential finishing step. Sand

being porous allows for better drainage and therefore reduces the risk of clogging of the filter.

The thickness of the layering varies with the water quality (or that of the product to be treated) so that the various constituents receive complete treatment. The size of filtration beds is established accordingly.

Gravel functions as a support which enables drainage. A geotextile material acts as a membrane separating the different layers. The required characteristics of the geotextile are established based on the nature of the waste to be purified.

Status Report

The project was completed in December 1990.

The system demonstrated its ability to remove a substantial amount of organics and metals from sewage. For example, removals in excess of 95% were achieved for oil and grease, cadmium, cobalt, copper, iron, lead, and zinc.

The proposed flowsheet is simple and needs no sophisticated equipment for its construction. Precise costs for construction and operation depend on volumes treated. Annual operating costs are in the \$ 0.018 to \$ 0.022/L (\$0.08 to \$0.10/gal) range.

Currently, the normal rate for septage removal and disposal is \$ 0.013 to \$ 0.015/L (\$0.06 to \$0.07/gal). Local governments and populations recognize that increased costs are inevitable if proper septage handling methods are to be instituted.

DRECT Contractor

Superwood Ontario Limited
Mississauga, Ontario

Other Cost-Sharing Partners: Ontario Ministry of
Environment

Scientific Authority: D. Hutchison
(819) 953-5228

Objective

To demonstrate a technology to
recycle mixed post-consumer
plastics recovered from the
municipal solid waste stream.

Project Description and Relevance

Recycling of post-consumer plastics has not been demonstrated to be economically feasible in North America. For the most part, these plastics are now either placed in landfill sites or incinerated with other waste. The primary objective of this project is to demonstrate a new technology in Canada for recycling such plastics. Specifically, an extruded product called "Superwood" with properties similar to that of dense hardwood will be produced from mixed plastic waste collected via the Mississauga blue box program. Superwood can be worked with conventional wood-working tools, and can be joined with nails and screws.

The process to be demonstrated uses mixed granulated waste plastic. After blending the mix of plastics, the material is extruded into a mould. The mould is then cooled, and the finished product ejected pneumatically. The whole manufacturing process is controlled automatically by a microprocessor using proprietary software. Products being produced by the Superwood group include: road furniture, such as delineators, markers and marker posts, poles, crash barriers, planters and benches; agricultural products, including stakes, slatted floors for animals, electric fence posts, gates and gate posts; industrial products such as pallets, underground cable covers, coastal and riverbank protection units; and fencing.

While there is considerable latitude in the specific resin mix used, the mix must be predominantly

polyethylene. These resins represent the largest portion of plastics in both domestic and industrial waste streams. By selective sourcing of the plastic used, the appropriate balance of resin types can be obtained. Major limitations for raw materials are to restrict the amount of chlorine-containing plastics (predominantly polyvinyl chloride) and thermoset plastics.

The Canadian Council of Ministers of the Environment has set as a goal a 50% reduction in waste generated in Canada, by the year 2000. The Province of Ontario has announced its intention to divert 25% of municipal solid waste from landfill and incineration by 1995, and to divert 50% by the year 2000. Plastics constitute about 7% by weight of municipal solid wastes. Their low bulk density, however, causes them to occupy about 30% by volume of the solid waste stream, and makes disposal of the combined waste much more difficult.

One of the contributors to Ontario's waste reduction goal will be an expansion of the blue box recycling program. As yet, however, recycling technology for plastics collected in this manner has not been demonstrated. Pressure is building, therefore, for plastics recycling technology.

For this project, the machine to be purchased will process about 181 kg/h (400 lb/h) of mixed plastics, or approximately 340 t/yr. Resource savings would therefore be those required to produce 340 t/yr of these plastics and energy savings would be

the process energy required to produce the plastic that is being recycled, 105 505 500 kJ/t (100 000 000 BTU/t), or approximately 3.4×10^{10} BTU/yr. This is equivalent to 5500 bbl of oil (874 m³ of oil).

Status Report

The Superflow Jumbo Moulding Machine, rated capacity of 200 to 250 kg/h, was delivered and installed in the Mississauga plant in June, 1990. Production started shortly thereafter. Structural and durability tests have been conducted on the Superwood products and results indicate benefits over wood products.

Problems are being encountered with the sale of Superwood products. The majority of all sales have been to private industry as opposed to municipalities and various government departments as was initially anticipated. The typical complication lies in the types of products offered by Superwood. Park benches, picnic tables, etc., are standard items that a municipality buys via a competitive bidding process. The products must meet certain standards, size and design and little consideration is given to future maintenance costs, such as repair, painting, etc., or life expectancy. These costs are normally taken from a different account and budget year. Unless changes are made in such government procurement policies, this particular problem will be difficult to overcome.

A final report will be available in December 1991.

Scientific Authority: G. Girouard
(514) 283-6536

Objectives

- 1) To design, construct, install, and operate a full-scale wastewater treatment process to treat 200 000 L/d of metal-finishing wastewater containing hexavalent chromium at concentrations of 26 mg/L; and
- 2) To recover chromium from the process in the form of commercial chromic acid.

Project Description and Relevance

The removal of chromium from industrial wastewaters is a serious problem. A 1983 survey by Environment Canada indicated that there were more than 600 surface-finishing companies nationally and that chromium was one of the most common finishes. It is now illegal in Quebec to discharge effluents containing more than 5 mg/L of chromium into municipal sewers or containing more than 1 mg/L of chromium into storm sewers.

There are currently a number of more or less successful ways to remove chromium from effluents. These involve chemical reaction and precipitation, ion exchange, reduction, ozonation, or electrodeposition. However, there are problems associated with all of these methods because of the requirement for hazardous reagents and skilled staff and the formation of toxic residues and sludges.

The new process for treating chromium-containing industrial wastewaters to be developed in this project is less complex and simpler to operate than current methods; does not generate toxic sludges; and permits recovery and reuse of the chemicals removed from the wastewater.

The Thermonic reactor is a one-step, liquid-solid interaction process that offers the potential to recover chromium IV (and possibly other metals) from process wastewaters and to recycle it back into the system or offer it for sale to other users. The process is designed to remove the chromium in two stages. In the first stage, chromium is extracted from the effluent and in the second stage it is recovered. An inorganic compound with a high affinity for dissolved chromium ions is used

to remove the chromium. The mixing process uses a "liquid/solid" interaction in a fluidized bed reactor to extract hexavalent chromium. The process is continuous and involves no previous reduction of the chromium. The reactant may be regenerated and reused.

For lack of a better alternative, plating shop effluents are often discharged to the sewer. Municipal sludges contaminated with heavy metals are difficult to dispose of. They cannot be land spread but must be incinerated, requiring considerable inputs of energy. Incineration requires approximately 4 GJ of energy per tonne of digested sludge. Given the number of surface finishers in Canada, a successful process which does not produce toxic sludges offers energy savings which are clearly substantial. The recovery of the chromium also offers energy savings compared with its production by mining and smelting.

There are also major potential environmental benefits. Many plating shops are moderate-sized operations and the cost and complexity of existing chromium removal systems discourages the installation of proper treatment facilities. Statistics show that the number of companies using offsite disposal has dropped 40% in the last ten years. This could indicate that more wastes are being disposed to sewer, possibly without any pretreatment. Given the legal situation in Quebec and the establishment of the Municipal and Industrial Strategy for Abatement (MISA) program in Ontario, such companies will

be faced with serious problems unless a simpler, cheaper treatment process is available.

Status Report

The performance evaluation of the effluent treatment unit for chromium extraction using the technology developed by Thermonic has shown promise for commercial application. The project provided the data needed for predicting potential environmental and economic advantages, as well as energy savings when using the process.

Some technical problems were encountered and careful examination is needed. The results of the chromium recovery and recycling laboratory tests are positive. However, the data must be verified on a larger scale to determine the economic and recycling value of the process. The recycling of the reactant must also be assessed on a larger scale in order to identify the most economical equipment. A high quality recycled product was obtained with the use of a plasma torch, but obviously, in a large-scale operation, it is not a feasible alternative. A number of pilot units has been set up to extract other metals, including zinc, nickel, lead, iron, and copper. It has been concluded that further testing is required before the Thermonic process for multiple metals extraction can be termed successful.

The project is complete and the final report is available. Ongoing development has been initiated under the St. Lawrence River Action Plan.

Scientific Authority: F. Laperrière
(819) 953-1118

Objective

Development and demonstration of a model recycling centre to serve a medium-sized municipality (i.e., population 50 000).

Project Description and Relevance

Optimization of processing lines at a municipal recycling centre involves maximizing the efficiency of equipment and manpower to produce products at an acceptable rate and cost. Marketability of products, even recycled products, depends upon the production of materials that meet the quality specifications of potential buyers and cost expectations of the recycling centre operators.

The project at Centre de tri Gaudreau Inc. is designed to evaluate the potential benefits of upgrading a four-year-old recycling operation. Prior to 1989, households in the Bois Francis region had to partially sort recyclable materials before collection and transportation to the recycling centre. Changes made to the recycling centre as part of this project will permit the collection of unsorted recyclables. All sorting of the collected materials will be completed at the refurbished centre.

The aim of the project is to demonstrate:

- 1) a more efficient method of collecting and processing post-consumer recyclables in a medium-sized municipality; and
- 2) the importance of developing reliable markets for recycled products.

The Bois Francis operation will be monitored over a two-year period. The outcome will provide a basis for comparing a curb-side separation/collection system with a mixed, recyclable material collection system and a central sorting/recycling facility. It is estimated that the project will include 10 000 t of recyclable

materials, including various grades of paper, glass, plastics, aluminum, and other metals. The 10 000 t goal represents 25% of the total waste generated annually in the region and is believed to be 10% higher than that attainable in the "blue box" program currently operating in other municipalities.

The potential environmental and energy-saving benefits of a 25% reduction in municipal waste generation are significant in the local area. A 25% reduction in municipal waste generation would extend the useful life of the existing landfill 8 to 10 years. Potential energy savings from the recycle and reuse of post-consumer materials have

been estimated to be equivalent to 10 000 BOE/yr.

Status Report

The project has been completed. Results indicate that the mixed-collection method had a positive financial impact on the recycling centre's profitability. However because of fluctuating markets for recycled products, it was also concluded that the operation required financial support from the municipality (i.e., \$ 4.00 to \$ 7.00 per residence per year) in order to remain a viable entity.

The goal of a 25% reduction in municipal waste generation was achieved.

DRECT Contractor**Fossetic Inc.**Sainte-Agathe-des-Monts, Quebec

Scientific Authority: G. Girouard
(514) 283-6536

Objective

To develop and demonstrate a
system for more effective
management of septic tank
sludge.

Project Description and Relevance

Wastewater disposal from residences in rural areas normally involves the use of septic tanks and tile fields. Conventional practice is to remove accumulated solids from the septic tank, along with the liquid supernatant, every two to three years. Given that the septic tank for a residence can have a capacity of 2500 L or more, septage can be a major disposal problem in rural areas. Municipalities are becoming increasingly restrictive with respect to the disposal of this material. Dumping septage into landfills or onto agricultural lands is no longer allowed in many jurisdictions. The operators of septage services are left with the dilemma of finding a disposal alternative that is acceptable to the municipality and economically feasible for the operator. Alternatives that are considered acceptable from the municipality's perspective (e.g., discharge of septage to a municipal wastewater treatment plant) may not be practical for the operators. A limited number of licensed disposal sites within a region can result in high transportation costs for some haulers and costly tipping fees. This project is part of a program to improve the handling and disposal of septage.

The work by Fossetic Inc. involves two aspects of septage management: collection; and treatment and disposal.

The practicality of a "selective pumping" collection system will be evaluated. The system involves the use of a multi-compartmented tank vehicle which permits the separate removal and storage of the liquid and solid contents of a septic tank. When the septic tank has been completely

cleaned and inspected, the liquid component is returned from a compartment in the tank truck to the septic tank. The proposed approach eliminates the hauling of large quantities of relatively "clean" liquid to a disposal site. The volume of sludge in a well-maintained septic tank represents 25% to 50% of the total contents of the tank.

The truck operator can make more service stops per load, transportation (energy) costs are reduced, and treatment and disposal costs will decrease. In addition, other options for treating septage, such as composting, become more feasible with the increased solids content of the septage.

The second phase of the project involves the development of storage and treatment facilities that are specifically adapted for septage processing. The proposed system includes a combination of lagoons, filter beds and composting operation, all aimed at providing an acceptable site for handling, treating and disposing of septic tank and holding tank wastes collected in the Sainte-Agathe-des-Monts region of Quebec.

Status Report

The initial phase of the Fossetic project began in 1986. After five years of development and operation, the selective pumping process has proven to be environmentally beneficial and commercially viable. Some of the

important facts identified as a result of the project include:

- 1) a 70% reduction in the volume of septage being generated and disposed of by the selective pumping process;
- 2) concentrated sludge can be removed from septic tanks with an effort comparable to conventional pumping methods; and
- 3) potential savings with respect to transportation (fuel and travel time) and disposal of collected wastes are significant; locally, it was estimated that selective pumping resulted in a 25% reduction in collection costs, 140% increase in return on investment, and an annual savings of 365 000 L of diesel fuel.

The second phase of the project examined alternative approaches to treating septage. Septage from a selective pumping service could be composted directly, without pretreatment. Septage removed via conventional pumping methods, or collected from holding tanks, required pretreatment. Two methods of pretreatment were evaluated, i.e., filter system and lagoon system. Results indicate that for small volumes of septage, of the order of 1 364 000 L/yr (300 000 gal/yr), the filter system was most economical, at an annual cost of \$0.010/L (\$0.045/gal). For septage volumes in excess of 2 728 000 L/yr (600 000 gal/yr), a lagoon system was more appropriate, at a cost of \$0.007 to \$0.008/L (\$0.03 to \$0.035/gal).

Scientific Authority: S. A. Ross
(819) 953-7827

Objective

To develop a simple, low technology composting process to provide a means to reduce the disposal problems associated with fish offal.

Project Description and Relevance

Canada's fish processing industry generates approximately 200 000 tonnes of fish offal (fish wastes) per year. In most cases these wastes are applied directly to agricultural lands, landfilled in bulldozed pits, or dumped into the sea. When spread on open fields, fish offal produces a very distinctive and disagreeable odour. Cultivation is necessary to eliminate this odour. This restricts the times of the year when landspreading can be utilized to summer months and, even then, only when the land is not being tilled or used for crops. Landfilling fish offal is known to cause smell and nutrient enrichment in adjacent surface and groundwaters. Dumping fish offal into coastal waters pollutes and interferes with estuarine ecosystems.

This project will apply and adapt a methodology originally developed by the Research Branch of Agriculture Canada for composting. In this project, fish offal, and peat moss will be mixed and placed in static windrows. The windrows will be covered to protect them from wind, rain and animals, allowed to compost for 30 to 90 days, then screened and formulated into products directed at specific markets. The resulting material will be evaluated for market potential.

Initially, four products will be test marketed:

- 1) Pure Sea - a natural, high nutrient, NPK compost fertilizer;
- 2) Nutrient 50 - a base nutrient product for clay and sandy soils;
- 3) Nutrient 60 - a product for vegetable gardens; and

- 4) Nutrient 70 - a product for flowers and house plants.

This fertilizer has the potential to displace large amounts of energy-intensive chemical fertilizers. When compared with bone meal produced from fish offal, composting offers savings of 2000 MJ/t of processed fish offal. In the Gaspé Region, which generates about

26 000 t of fish offal annually, this represents potential annual savings of 50 000 GJ or 7 800 BOE.

Status Report

The project was started in late 1990 and is scheduled for completion in January 1993. No results are available at this time.

DRECT Contractor

Ottawa General Hospital
Ottawa, Ontario

Scientific Authority: F. Laperrière
(819) 953-1118

Objective

To develop two essential tools
for a reduction and recycling
program in the hospital sector:

- 1) A model waste audit process; and
- 2) Recyclable Packaging Materials.

Project Description and Relevance

Trends in hospitals over the last decade have been in the direction of disposable supplies. Disposables are convenient, they reduce labour inputs and are perceived to offer better protection from infection for both patients and staff. These are good and logical reasons but, as a result, an estimated 550 000 kg of wastes are produced in hospitals in Canada every day. Only 10 to 15% of these wastes need special treatment and disposal and the rest are landfilled. There would therefore appear to be considerable scope for reduction, recycling, or recovery.

Waste management is becoming expensive and the materials discarded represent a potential energy loss compared with recycling them to displace virgin materials. Virgin materials tend to require more energy to produce than their recycled equivalent.

The first step towards minimizing the wastes produced is to inventory them. The first part of this project will develop a standardized audit process for providing a self-directed, easy-to-follow approach which can be utilized by hospitals across Canada who wish to conduct their own audits.

An experimental audit will be conducted at the Ottawa General Hospital and a methodology will be built based on the experience gained. It is expected that the methodology will address materials flows and balances, in and out; types of wastes, the way in which they are handled; potential for reduction, reuse, or recycling; and currently available markets. The information collected will be analyzed and refined. The

practicalities and financial aspects of implementing waste reduction practices in a hospital context will be considered with particular concern for maintaining safe and efficient practices and procedures.

Finally a model will be developed which can be used by the Ottawa General Hospital to identify opportunities and monitor progress as reduction programs are implemented.

The second step will be to examine current methods of pharmaceutical packaging in cooperation with a leading Canadian manufacturer of pharmaceuticals with a view to substituting packaging that will be easier to recycle. The packaging will be tried and evaluated at the Ottawa General Hospital.

Status Report

The project started in mid-1990. A final report is expected in December 1991.

Scientific Authority: S. A. Ross
(819) 953-7827

Objective

To demonstrate that packaging products acceptable to high technology industries can be manufactured from PVC feedstocks containing 30 to 60 % recycled material.

Project Description and Relevance

An estimated 823 000 tonnes of plastic wastes are landfilled each year in Canada. This project will involve the development and demonstration of a new process for manufacturing reusable packaging products from rigid and flexible PVC feedstocks incorporating the highest possible content of reprocessed materials. This has the potential not only to divert some of the wastes previously quoted from landfill and provide energy savings by displacing virgin materials but it will also produce economic benefits for manufacturers and suppliers of plastic packaging products.

The technical and economic feasibility will be judged on the following :

- 1) Demonstration that the thermoforming and high frequency sealing processes are capable of achieving a minimum acceptable yield of 80% from both rigid and flexible PVC films composed of 30% to 60% recycled materials.
- 2) Demonstration that the thermoforming and high frequency sealing processes can operate as efficiently and cost effectively using either virgin or recycled PVC materials as feedstock in the manufacturing process.
- 3) Demonstration that the packaging products which are produced with recycled PVC are of acceptable quality for use by the high technology industry.
- 4) Demonstration that the use of recycled PVC materials as feedstock results in economic benefit to the manufacturers of packaging products.
- 5) Demonstration that the use of recycled PVC materials in the production of rigid and flexible

PVC films can be a potential economic and marketing advantage to film producers in Canada.

Status Report

The technical and economic feasibility of using PVC with a high percentage of recycled resin in the Pacware manufacturing facility was confirmed during the DIRECT project.

Rigid PVC containing a minimum of 40% regrind material and flexible PVC with a

95% regrind content were tested. Inhouse quality assessment of the finished product, a diskette packaging product, revealed positive results with respect to general appearance, durability, functionality, crush resistance, and temperature resistance. The company estimated a savings of \$4000 to \$5000/yr for small manufacturers using PVC containing reprocessed material.

DRECT Contractor

Prairie Masonry Research Institute (PMRI)
Edmonton, Alberta

Scientific Authority: S. A. Ross
(819) 953-7827

Objective

To develop new masonry units using waste materials, notably waste wood chips and sawdust.

Project Description and Relevance

The Prairie Masonry Research Institute has been involved in several research and development activities designed specifically to improve the use of masonry in Canada. Concrete blocks using lightweight aggregate for better thermal performance and easier handling are widely used in masonry construction where loadings allow. This project involves the use of waste wood chips and sawdust as a replacement for conventional thermally processed clay aggregate.

PMRI estimates that the technology, if proven, could save fuel equalling 1500 BOEs per day in block manufacture if the thermally processed clay aggregate can be eliminated.

An estimated 95 000 000 m³ of wood residues are generated by the logging and lumber industries in Canada each year. Half of this amount is disposed of by landfilling or uncontrolled burning of wood wastes. A new use for these materials would therefore have significant environmental benefits.

Technical and economic feasibility will be judged by the following:

- 1) Demonstration that the process will have no effects harmful to the environment or human health.
- 2) Demonstration that the product will be comparable in strength, structural behaviour, fire resistance, and sound transmission with conventional lightweight aggregate blocks.
- 3) Demonstration that a 30% reduction in cost and a 6-kg reduction in weight compared with

conventional lightweight aggregate blocks can be achieved.

Status Report

The project was started in mid-1990 and is scheduled to be completed in February 1992.

Phase I of the project, which covered the experimental program, concrete mix design, agreement with a concrete block manufacturer/supplier, and environmental monitoring program design, is now complete.